MAY 14 1959

PILOT CONSIDERATIONS IN THE X-15 RESEARCH AIRPLANE PROGRAM

By Walter C. Williams
NASA High-Speed Flight Station

For presentation at the Annual Meeting of the
American Psychiatric Association
April 29, 1959
Philadelphia, Pennsylvania

N65-83302
Code None
Nasa tmx 56264

The X-15 research airplane will take a man for brief journeys to the fringe of space. It is the latest vehicle to join the joint Air Force-Navy-National Aeronautics and Space Administration research airplane program.

Before discussing some of the pilot considerations, perhaps it would be best to see just what this X-15 airplane looks like. In the first slide it can be seen that the airplane is relatively conventional in appearance. Its differences lie underneath. The structure, rather than being of the usual aluminum alloys, is Inconel, a nickle alloy.

The X-15, of course, is propelled by a rocket engine. It is carried aloft under the wing of a modified B-52 bomber, then released (slide 2). After release the pilot starts the rocket engine and is on his way. As a matter of interest, the pilot enters the X-15 while it is still on the ground and rides in it for a period of more than an hour all through the take-off, climb, and cruise out to the drop point. During this time he is, of course, in radio communication both with the B-52 crew and with the ground stations.

The X-15 is not a true space ship in the sense of interplanetary travel. However, its flight profile will enable a study of a number of the problems associated with space flight. To illustrate, a typical mission is shown on the next slide (3). The airplane in its design mission will be launched over Wendover, Utah, where large salt flats will allow emergency landing should the X-15 engine fail to start. Then it will be flown to Edwards over an instrumented range--there are radar and telemetry stations at Ely and Beatty, Nevada, and Edwards Air Force Base, Calif. The pilot will be in functional command of the entire flight. After starting the engines, he

will rotate the airplane into a climb. During this period he will be required to exercise precise control while experiencing reasonably high values of transverse acceleration. At burnout, the airplane will coast to higher altitude on a ballistic flight path where the pilot will be exposed to zero g, or weightlessness. This will represent space flight. The pilot will then be required to make an entry into the atmosphere, as he would if he were returning from a space mission, glide back to the base, and land at Edwards. In this typical mission we have many of the elements of a space flight.

Now let us consider briefly the pilot's working space and environment. Since he will be operating in an acceleration field, the controls have been arranged for the best possible functioning under these conditions, as shown in the next slide (4) which illustrates the right side of the cockpit of the airplane. It should be noted that there are two control columns, rather than the standard one, to control the airplane in aerodynamic flight. The usual center stick has been used and, in addition, there is a controller on the right side of the cockpit for controlling the airplane under high g conditions. The pilot can actuate this control simply by moving his hand; no arm motion is required. On the left side is a control (slide 5) for the space controls, which are small rockets positioned on the airplane to control its attitude during those phases of flight where aerodynamic forces are negligible or where there is no air. The pilot's atmosphere in the cabin is nitrogen, so he is actually sitting in a hostile atmosphere. The nitrogen gas used to pressurize the cabin will also be used to cool it, since it will be derived by boil-off from liquid nitrogen. The pilot's direct environment, however, is controlled by a pressure suit. This suit will provide breathing oxygen as well as emergency pressurization in the event of a cabin-pressure failure. In addition,

there is an insulating garment that is cooled by nitrogen circulated between the pressure layer of the suit and the body so that direct ventilation is provided for the pilot.

Now that we've described the airplane and the pilot's working environment, let's look at the man and how he has prepared himself to fly this airplane. Psychological problems, per se, have not been investigated on an active basis, but have been minimized by passive means. The pilots actively participate in the program so that it will not represent a vast unknown area to them when they actually begin flying the missions. The next slide (6) shows some of the characteristics of the pilots pertinent to the job at hand. This listing includes eight pilots, all of whom will take part in the X-15 program. They represent the manufacturer--North American Aviation, Inc., the Air Force, Navy, and test pilots from the High-Speed Flight Station of the National Aeronautics and Space Administration. Looking at the average characteristics, we find that the pilot is 35 1/2 years old and has been flying for 15.1 years. We are using years of flying rather than hours because all these men are fighter pilots and have also spent an appreciable period of their time, 6.6 years on the average, as test pilots. Therefore, hours, as such, do not necessarily give a true picture of the pilot's experience and ability. All the men have at least four years of college. Each has a Bachelor's degree, and several have advanced degrees. So, actually what we have here is a picture of the average professional engineering test pilot, the type to whom a job such as this represents an advancement in his profession. They are all voluntarily in the profession, so the creation of motivation is no problem. All are married, and all have children varying in number from two to six.

These pilots, of course, have lived with this program since its inception because they could make valuable contributions to the design based on their experience in flying previous research airplanes. They contributed heavily to the cockpit design, with regard to arrangement of controls and instruments, for example (slide 7).

As the program advanced and design became firm, simulator programs were begun. These programs involved the use of equipments which completely reproduced the control system, the mockup of the cockpit, and its instrument presentation (slide 8). By means of a tie-in with the proper type of computers, the pilots could actuate the controls and see the response on the instrument panel. In this manner, then, they could go through the entire flight envelope of the airplane, evaluating the presentation and the control system. Since, in this case, we knew the pilot would be subjected to an acceleration field greatly in excess of any he had experienced before, we felt that simulation including acceleration should be accomplished. To do this, the human centrifuge at the Naval Air Development Center, Johnsville, Pennsylvania, was used and modified so that it, too, could be tied into a computer. The pilot could then "fly" the centrifuge so that any action he took would be reflected in the accelerations on the centrifuge (slide 9 - and short film showing Johnsville centrifuge and the pilot going through a typical run). On the centrifuge, then, we were able to evaluate the acceleration problem and further evaluate the instrument presentation and location of controls. One more unknown had been removed for the pilot. Now he knew that in the g field of the X-15, he would be able to handle the airplane. In a sense our approach throughout the program has been to remove as many of the unknowns as possible prior to flying the airplane.

Another area of concern to us was landing a vehicle such as the X-15. We have found that by using some of our modern jet fighters, such as the F-104 and F-100, and suitably modifying them, particularly with drag-producing devices, we have been able to simulate, to a degree, the landing characteristics of the X-15. Out of this has been developed a landing pattern and a landing technique. Again the pilot has become familiar with an area of the X-15 flight before he actually flies the airplane.

As mentioned earlier, the pilot's prime environment is provided by the full-pressure suit. This suit provides for breathing under normal conditions. It is also a ventilation garment that will provide protection against both heat and cold. Under emergency conditions, such as a cabin-pressure failure, it will provide overall pressure. This pressure suit is not an entirely new piece of equipment, even though there are some new concepts used, but it is a natural outgrowth of similar suits. This particular one, however, is more comfortable and provides more mobility than had been provided previously. These suits, which are tailored to the individual pilot, have been worn by the pilots in pressure chambers to altitudes above 200,000 feet, and they have been subjected to extreme heat and cold (slide 10). To further familiarize the pilot with the suit environment and operation, we have used a two-place TF-102 airplane in which it is possible for the pilot, while wearing the suit, to be carried to altitude and actually fly the TF-102 both pressurized and unpressurized. In this way he gains an instilled confidence that under any circumstance, as far as the suit is concerned, he can handle an airplane.

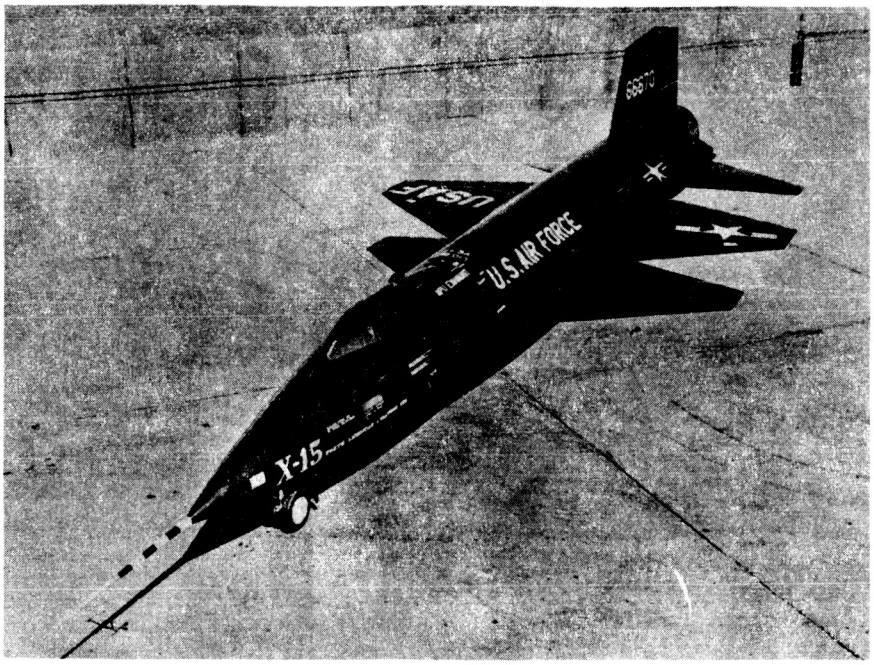
Of course, in a program such as this, or in any flight test program, the pilot always wants a way out of a hazardous situation. He knows by the engineering design that all systems are backed up, and that, in the event of one failure, there is redundancy in the system that should provide for satisfactory recovery of the airplane and pilot. However, in the event

of some unforeseen occurrence, for example, fire at the time of starting the engines, an escape system in the form of a stabilized ejection seat has been provided in the X-15. This seat has been thoroughly tested on a high-speed track at Edwards. It has been ejected and the whole escape system functionally proven. The system provides for automatic release of the pilot restraint--the seat belts and harness--and also automatic deployment of the pilot's parachute so that even though injured he could be recovered. So, the pilot has reasonable assurance of recovery regardless of what happens to the airplane.

Probably the most important aspect of the X-15 flight program is that it will not consist of one all-out flight where, immediately, the pilot would experience high g forces during boost, weightlessness during the space portion of the flight, high accelerations again, with the requirement for precise control during reentry and navigation back to the base, and then landing this machine--all for the first time. But, rather, it will consist of a series of build-up flights by which we will expand our knowledge about the airplane as well as the pilot's reaction to the environment. Of course, the pilots will actively participate in the review and analysis of all the flight data and will participate in all decisions regarding the next steps to be taken. During this build-up phase, the pilots will be monitored carefully by a flight surgeon who has been assigned to the program. The surgeon has coordinated all human-factors activities and has lived with the program in the same manner as the X-15 pilots and engineers. When, during the flight test, we actually monitor the pilot's physical condition, these data will be telemetered to the ground and observed by the flight surgeon. Some of the information to be measured and telemetered includes the pilot's body-surface temperature, electrocardiographic data, differential pressures between the suit and the

cockpit, and the differential between the helmet and the suit, since the helmet is separate. From these data the surgeon will be able to determine which are the stressful parts of the flight and what the pilot's limitations may be in this regard. In addition, from the radiation standpoint, use will be made during the flight tests of the whole-body radiation counter at the Los Alamos Scientific Laboratory so that after each exposure to extreme-altitude flying, the pilot's radiation count will be checked.

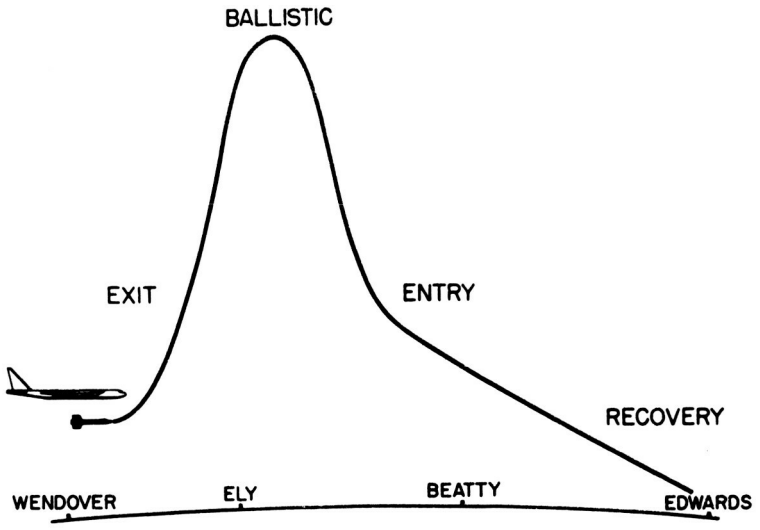
In conclusion, it might be said that our whole objective has been to remove as many unknowns as possible for the pilot before the flight, and to assure that his actual flight training and the actual flight test program proceed in such a manner that the task becomes a realistic continuation of previous experiences and training.



1

2

X-15 RESEARCH OBJECTIVE REGIONS



3

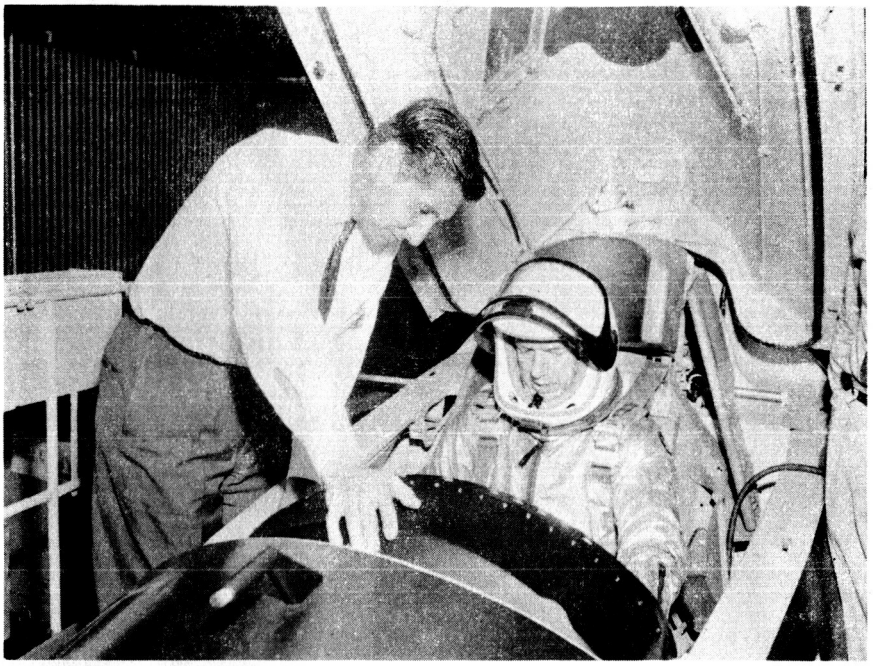
4

5

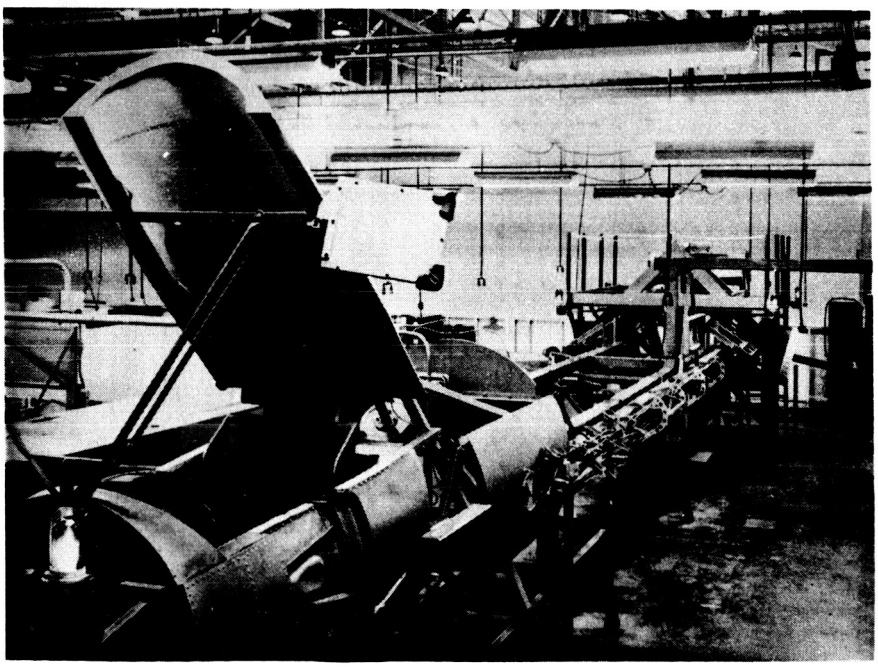
X-15 PILOT STATISTICS

	AVERAGE	MAXIMUM	MINIMUM
AGE	35.6	41	28
YEARS OF FLYING	14.9	18	8
YEARS OF TEST FLYING	6.8	14	3.5
EDUCATION	4.5	6	4

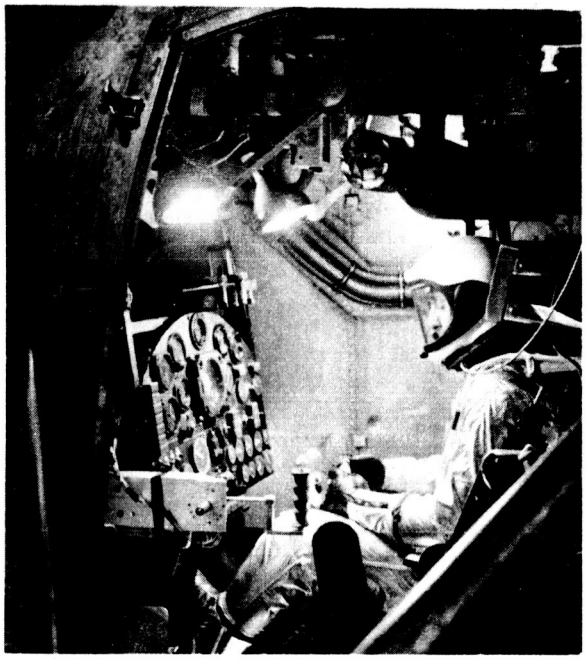
6



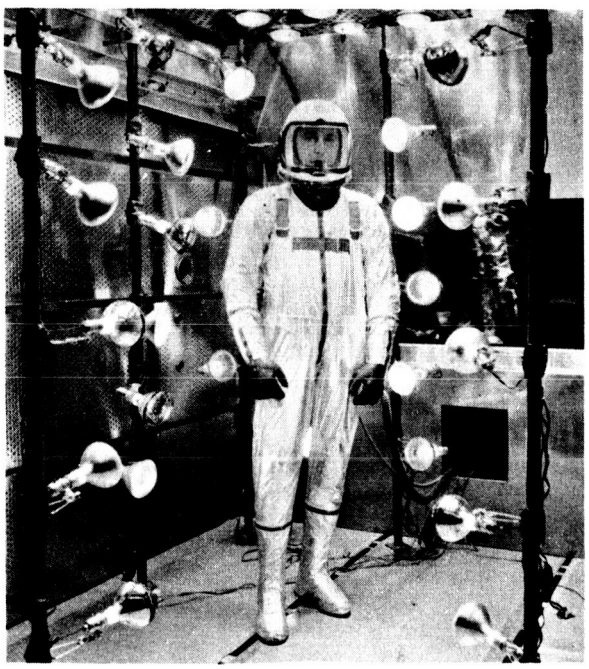
7



8



9



10